

## NICKEL HYDROXIDE PASTE WITH PECTIN BINDER

### **Field of the Invention**

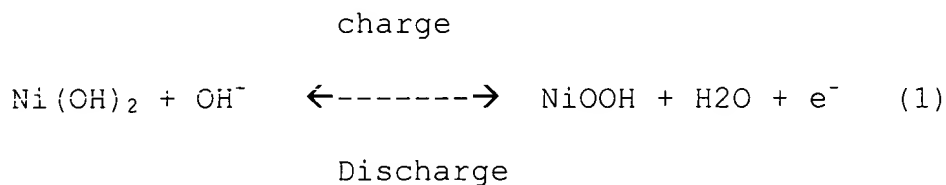
The present invention relates to alkaline  
5 electrochemical cells. In particular, the present  
invention relates to active compositions for electrodes of  
alkaline electrochemical cells.

### **Background of the Invention**

10 Rechargeable electrochemical cells may be classified  
as "nonaqueous" cells or "aqueous" cells. An example of a  
nonaqueous electrochemical cell is a lithium-ion cell which  
uses intercalation compounds for both anode and cathode,  
and a liquid organic based or polymer electrolyte. Aqueous  
15 electrochemical cells may be classified as either "acidic"  
or "alkaline". An example of an acidic electrochemical  
cell is a lead-acid cell which uses sulfuric acid as the  
electrolyte, lead dioxide as the active material of the  
positive electrode, and metallic lead, in a high-surface  
20 area porous structure, as the negative active material.

Examples of alkaline electrochemical cells are  
"nickel-based" alkaline cells. These cells use an alkaline  
electrolyte (such a potassium hydroxide) and nickel  
hydroxide as the active material for the positive

electrode. Nickel hydroxide has been used for years as an active material for the positive electrode of alkaline batteries. The reactions that take place at the positive electrode of a nickel-based rechargeable electrochemical cell are reversible and include the following chemical reaction:

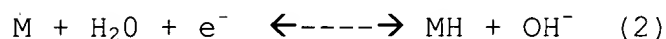


At the positive electrode,  $\text{Ni(OH)}_2$  is oxidized to  $\text{NiOOH}$  during the charge operation. During discharge, the  $\text{NiOOH}$  is reduced to  $\text{Ni(OH)}_2$ . Examples of such nickel-based alkaline batteries include nickel-metal hydride cells (Ni-MH), nickel cadmium cells (Ni-Cd), and nickel-zinc cells (Ni-Zn). Ni-MH cells used negative electrode using a hydrogen storage alloy as the active material. The hydrogen storage alloy is capable of reversible electrochemical storage of hydrogen.

In general, Ni-MH cells utilize a negative electrode that is capable of reversible electrochemical storage of hydrogen, and a positive electrode of nickel hydroxide material. The negative and positive electrodes are spaced apart in the alkaline electrolyte.

Upon application of an electrical potential across a Ni-MH cell, the hydrogen storage alloy of the negative electrode is charged by the electrochemical discharge of hydrogen and the electrochemical generation of hydroxyl ions:

Charge



Discharge

10 The negative electrode reactions are reversible. Upon discharge, the stored hydrogen is released to form a water molecule and release an electron. (In a Ni-Cd cell, cadmium metal is the active material in the negative electrode).

15 The active electrode material for both the positive and negative electrodes is usually affixed to a conductive substrate to form the positive and negative battery electrodes. One way to affix the active material to the conductive substrates is to first make the active materials  
20 into a paste by adding a small amount of binder and then applying this paste to the substrate. The present invention is directed to a new active material composition including a binder comprising a monosaccharide, a disaccharide, a pectin or a molasses. Electrodes

incorporating this active composition have improved electrochemical and mechanical properties.

### **Summary of the Invention**

5       An object of the present invention is an electrode and an electrochemical cell having increased power. Another object of the present invention is an electrode and electrochemical cell having improved cycle life.

10       These and other objects of the invention are satisfied by an active composition for an electrode of an alkaline electrochemical cell, comprising: an active electrode material; and a binder comprising a monosaccharide, a disaccharide, a pectin or a molasses.

15       These and other objects of the invention are also satisfied by an electrode for an alkaline electrochemical cell, comprising: an active composition including: an active electrode material; and a binder comprising a monosaccharide, a disaccharide, a pectin or a molasses.

20       These and other objects of the invention are also satisfied by an alkaline electrochemical cell, comprising: at least one positive electrode; at least one negative electrode; and an alkaline electrolyte, the positive electrode and/or the negative electrode having an active material composition including a binder comprising a  
25       monosaccharide, a disaccharide, a pectin or a molasses.

## Detailed Description of the Invention

Disclosed herein is an active material composition for use in an electrode of an alkaline electrochemical cell. Generally, the active material composition comprises an active electrode material and a binder. The binder comprises a monosaccharide, a disaccharide, a pectin or a molasses. In addition, the binder may be a mixture of one or more of a monosaccharide, a disaccharide, a pectin or a binder.

Examples of a monosaccharide include glucose, fructose, and galactose. An example of a disaccharide is maltose. An example of a pectin is a fruit pectin such as a citrus fruit pectin and an apple pectin. An example of a molasses is the liquid left after sucrose has been removed from the mother liquid in sugar manufacture.

Generally, the active electrode material may either be a positive electrode material or a negative electrode material. Examples of positive electrode materials include nickel hydroxide, manganese dioxide, zinc oxide, nickel oxide, manganese hydroxide, copper oxide, molybdenum oxide, carbon fluoride, etc. Examples of negative electrode materials include zinc, cadmium hydroxide, hydrogen storage alloys, etc.

Preferably, the active electrode material of the present invention is a nickel hydroxide material. It is within the spirit and scope of this invention that any nickel hydroxide material be used as the active material.

5 Example of nickel hydroxide materials are provided in U.S. Patent Nos. 5,348,822 and 5,637,423, the contents of which are incorporated by reference herein.

As described, the active composition comprises an active electrode material and a binder comprising a  
10 monosaccharide, a disaccharide, a pectin or a molasses. Preferably, the binder comprises a pectin or a molasses. In one embodiment of the invention, the binder comprises a pectin. Preferably, the binder consists essentially of a pectin. In another embodiment of the invention, the binder  
15 comprises a molasses. Preferably, the binder consists essentially of a molasses.

The binder is preferably intermixed with the active electrode material. More preferably, the binder is intermixed with the active electrode material so as to form  
20 a paste. Hence, if the binder is in solid form, it is preferably dissolved in an appropriate solvent before being mixed with the active electrode material. After, the binder is dissolved, the active electrode material is added in order to form an active paste composition.

Preferably, the binder is between about 0.1% and 2.0% by weight of the active material composition. More preferably, the binder is between about 0.2% and about 0.8% by weight of the active material composition. Most  
5 preferably, the binder is between about 0.3% and about 0.5% by weight of the active material composition.

An example of an active electrode composition of the present invention comprises about 88.6 wt% nickel hydroxide, about 5 wt% cobalt, about 6 wt% cobalt oxide,  
10 and about 0.4 wt% pectin.

Also disclosed herein is an electrode for use in an alkaline electrochemical cell. The electrode comprises the active material composition disclosed above. The active material composition is affixed to a conductive substrate  
15 in order to form the electrode. The conductive substrate is used as a support and as a current collector for the active material composition. The electrode is formed by first forming the active composition. Mixing the active material with the binder (in solution) forms a paste which  
20 may be applied to the conductive substrate to form an electrode. After the paste is applied to the conductive substrate, the resulting electrode may then be allowed to dry. After the electrode is dried, it may then be compacted so as to obtain the required thickness.

Compaction may be accomplished through the use of one or more rolling mills.

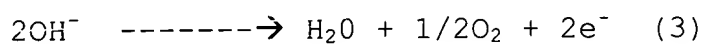
The conductive substrate may be any electrically conductive support known in the art capable of holding the active material composition. It is within the spirit and intent of this invention that any and all kinds of electrically conductive substrates may be used. Examples of substrate include foam, perforated metal, expanded metal, screen, matte, and a metal foil. Generally, any metal may be used as long as it is immune from corrosion at the pH and potential of the electrode. Examples of metals include nickel, nickel alloy, nickel plated steel, and nickel plated copper. Substrate for the negative electrode may further include copper or copper alloy. In one embodiment, the substrate is in the form of a metal foam comprising nickel, nickel alloy, nickel-plated steel (i.e., steel which is plated with nickel), or nickel-plated copper (i.e., copper which is plated with nickel). Preferably, the metal foam comprises nickel or a nickel alloy. Other forms of substrate (for example, a nickel foil) may be used to make a thinner electrode. One embodiment of the electrode of the present invention is a nickel hydroxide electrode using an active material composition comprising nickel hydroxide and pectin.



Also disclosed herein is an alkaline electrochemical cell comprising at least one positive electrode, at least one negative electrode, and an alkaline electrolyte. The positive electrodes and/or the negative electrodes may be  
5 formed using the active material composition of the present invention. That is, the positive electrodes may be formed using an active positive electrode material and a binder comprising a monosaccharide, a disaccharide, a pectin or a molasses. Also, the negative electrode may be formed using  
10 an active negative electrode material and a binder comprising a monosaccharide, a disaccharide, a pectin or a molasses.

For example, a Ni-MH electrochemical cell may be formed by using positive electrodes having an active  
15 composition comprising a nickel hydroxide material and pectin. The negative electrodes comprise a hydrogen storage alloy as the active electrode material. Optionally, the negative electrodes may, in addition, have an active composition formed using a hydrogen storage alloy  
20 mixed with a pectin binder. Typically, the alkaline electrolyte is an aqueous solution of an alkali metal hydroxide such a potassium hydroxide, lithium hydroxide, sodium hydroxide or mixtures thereof.

The addition of a pectin binder to an active electrode material, such as a nickel hydroxide material, improves the durability and cycle life of the electrode. Specifically, during the charging process of a sealed nickel-metal  
5 hydride battery, the positive electrode reaches full charge before the negative and begins to evolve oxygen,



- 10 The evolved oxygen can oxidize the positive electrode and cause its mechanical disintegration, thereby reducing the electrode's cycle life. In particular, the oxidation can reduce the adhesion and electrical conductivity between the active nickel hydroxide particles and the substrate,  
15 thereby increasing the electrode's resistance and reducing the amount of power available for output.

The pectin binder is resistant to oxidation. Hence, while not wishing to be bound by theory, it is believed that the pectin binder protects the electrode from  
20 oxidation and deterioration, thereby increasing the integrity and cycle life of the electrode. Furthermore, because it is resistance to oxidation, it is also believed that the pectin binder improves both the particle-to-particle and particle-to-substrate adhesion. The improved

adhesion provides for better electrical contact (i.e., improved electrical conductivity) between the active particles and the substrate so as to reduce the internal resistance of the electrode. Hence, less power is wasted  
5 due to internal dissipation and more power is available to apply to an external load.

In addition to increasing power, the improved adhesion keeps the active electrode material together thereby reducing the chance that active material particulate may  
10 become loose and penetrate one of the separators to cause an electrical short. The improved adhesion also increases the flexibility of the electrode. Hence, the electrodes may be twisted, bent and wound more easily.

The improved adhesion also allows for making thinner  
15 electrodes. This may be accomplished by using a thinner substrate, such as a foil substrate, for supporting the active material. Because of the improved adhesion, the active composition remains attached to the thinner substrate. Thinner electrodes may also be made by  
20 increasing the amount of force used when compacting the active material onto the substrate. Using thinner electrodes allows for a greater number of electrodes to be placed within the case of the electrochemical cell. This also increases the power of the electrode and cell.

Example

A first active positive electrode paste (the "control" material) was prepared using 88.6 wt%  $\text{Ni}(\text{OH})_2$ , 5.0 wt%, Co, 5 6 wt% CoO and 0.4 wt% PVA binder (polyvinyl alcohol) binder. The paste was affixed to a nickel foam substrate to form a "control" positive electrode.

A second active positive electrode paste was prepared using 88.6 wt%  $\text{Ni}(\text{OH})_2$ , 5.0 wt%, Co, 6 wt% CoO and 0.4 wt% 10 pectin. The pectin is a citrus pectin. The paste was affixed to nickel foam substrates to form "pectin" positive electrodes.

A third active positive electrode paste was prepared using 88.6 wt%  $\text{Ni}(\text{OH})_2$ , 5.0 wt%, Co, 6 wt% CoO and 0.4 wt% 15 molasses. The paste was affixed to nickel foam substrates to form "molasses" positive electrodes.

Using the above identified "control", "pectin" and "molasses" positive electrodes, three nickel metal hydride electrochemical cells were made using negative electrode 20 comprising the same hydrogen storage alloy. All of the cells were cycled (charged/discharged) using the same procedure and the peak power was measured at 50% DOD ("depth of discharge") and at 80% DOD. The results are

presented in the Table. The peak power is provided in Watts per kilogram (W/kg).

Table

5	<u>Peak Power (W/kg)</u>	<u>50% DOD</u>	<u>80% DOD</u>
	Control	254	226
	Pectin	274	238
	Molasses	286	238

10        It is to be understood that the disclosure set forth  
herein is presented in the form of detailed embodiments  
described for the purpose of making a full and complete  
disclosure of the present invention, and that such details  
are not to be interpreted as limiting the true scope of  
15 this invention as set forth and defined in the appended  
claims.